HL 47: Transport in high magnetic field/quantum-Hall-effect

Time: Thursday 15:45–18:15 Location: H14

HL 47.1 Thu 15:45 H14

Influence of Interactions on Flux and Back-gate Period of Quantum Hall Interferometers — •Bernd Rosenow and Bertrand Halperin — Department of Physics, Harvard University, Cambridge, MA 02138, USA

In quantum Hall systems with two narrow constrictions, tunneling between opposite edges can give rise to quantum interference and Aharonov-Bohm-like oscillations of the conductance. When there is an integer quantized Hall state within the constrictions, a region between them, with higher electron density, may form a compressible island. Electron-tunneling through this island can lead to residual transport, modulated by Coulomb-blockade type effects. We find that the coupling between the fully occupied lower Landau levels and the higher-partially occupied level gives rise to flux subperiods smaller than one flux quantum. We generalize this scenario to other geometries and to fractional quantum Hall systems, and compare our predictions to experiments.

HL 47.2 Thu 16:00 H14

Investigation of CdSe/ZnSe quantum dots by surface sensitive x-ray diffraction — •Isabella Gierz, Christian Kumpf, and Eberhard Umbach — Experimentelle Physik II, Universität Würzburg, Am Hubland, 97074 Würzburg

In semiconductor heterostructure systems with a lattice mismatch of a few percent between substrate and epilayer nanometer-sized islands form spontaneously during growth. Within these islands electrons are confined in all three dimensions. For future quantum dot applications islands with homogeneous size distribution, a high surface density, and a defect free crystal lattice are needed.

We investigated CdSe/ZnSe quantum dots with a lattice mismatch of 7%. Grazing incidence x-ray diffraction measurements were performed at the BW2 beamline of HASYLAB using the Risø six-circle diffractometer. The data was analyzed using an iso-strain model developed by I. Kegel [1]. This method allows to determine height, lateral radius, gradient of relaxation, and chemical composition of the islands. Furthermore, we present model calculations for reciprocal space maps and results from AFM measurements to verify the results obtained by Kegel's method.

[1] I. Kegel et al "Nanometer-Scale Resolution of Strain and Interdiffusion in Self-Assembled GaAs/InAs Quantum Dots", Phys. Rev. Lett. **85**, 8 (2000).

HL 47.3 Thu 16:15 H14

Tunneling spectroscopy of the Landau band gaps of two laterally coupled quantum Hall systems — •Matthias Habl[1], Matthias Reinwald[1], Max Bichler[2], Gerhard Abstreiter[2], and Werner Wegscheider[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg — [2]Walter Schottky Institut, Technische Universität München, 85748 Garching

With the technique of cleaved-edge overgrowth it is possible to produce AlGaAs/GaAs-heterostructures where two quantum Hall systems are separated by an atomically precise barrier. A small barrier width on the order of the magnetic length ℓ_B leads to a Landau band structure with anticrossings lying in the achievable range of the Fermi level. While Kang *et al.* used modulation-doped 2DESs [1], the gate electrode introduced in our sample structure allows to investigate a certain band gap at different magnetic fields [2]. Therefore, though the barrier has a fixed width of $a = 52\,\text{Å}$ and a height of $V_0 = 268\,\text{meV}$, the effective shape (in units of ℓ_B and $\hbar\omega_c$) of the barrier as well as of the Landau band structure can be tuned by means of the magnetic field while the Fermi level is varied independently. The exact calculation of the one particle energy dispersion yields for an increasing field strength a slight rise of the position of the Landau band gaps on the scale of the cyclotron energy. This phenomenon is confirmed by the experimental data. In addition, interference effects at random tunneling centers in the barrier are discussed in dependence of the electron density.

[1] W. Kang *et al.*, Nature (London) **403**, 59 (2000)
[2] M. Habl *et al.*, Phys. Rev. B **73**, 205305 (2006)

HL 47.4 Thu 16:30 H14

The screening picture of the integer quantized Hall effect — •Afif Siddiki — Physics Dept., ASC, CeNS, LMU Munich, Germany

We implement the self-consistent Thomas-Fermi-Poisson approach to a homogeneous two dimensional electron system. First we summarize the findings of a recent model explaining the exact quantization of the Hall plateaus and the transition between them, within a local Ohm's law. Second we compute the electrostatic potential produced inside a semiconductor structure by a quantum point contact placed at the surface of the semiconductor and biased with appropriate voltages. The model is based on a semianalytical solution of the Laplace equation. Starting from the calculated confining potential, the self-consistent (screened) potential and the electron densities are calculated for finite temperature and magnetic field. We observe that there are mainly three characteristic rearrangements of the incompressible edge states which will determine the current distribution near a QPC.

HL 47.5 Thu 16:45 H14

Edge versus bulk current in the quantum Hall effect regime — •Josef Oswald — Institute of Physics, University of Leoben, Franz Josef Str. 18, A-8700 Leoben, Austria

The question about the role of edge and bulk current for the integer quantum Hall effect (IQHE) is still a major topic of the ongoing discussions. The importance of this question is highlighted by experimental results obtained by probing the lateral potential distribution in the IQHE-regime[1]. In order to compare this experimental results with theory, a transport model is needed, which is able to capture sample properties close to the real experimental conditions like e.g. sample geometry and non-ideal contacts. In recent papers [2,3,4] we have demonstrated, that on the basis of a network model it is possible to account for complex sample geometries and we have further shown, that our network model is able to treat edge and bulk currents on an equal footing. This gives us the ability to address the lateral current distribution in QHE samples. For the pure plateau regime we get a homogeneous distribution of the current in the bulk region, while for the transition regime between plateaus we get an enhancement of the current density near the edges.

[1] E. Ahlswede et al., Physica E12, 165 (2002)
[2] J.Oswald et al., Phys. Rev. B74(15), 153315 (2006)
[3] M.Oswald et al., Phys.Rev. B72(3), 035334 (2005)
[4] J.Oswald et al., J. Phys.: Condens. Matter 18, R101-R138 (2006)

HL 47.6 Thu 17:00 H14

Compressibility stripes for mesoscopic quantum Hall samples — •Christoph Sohrmann and Rudolf A. Römer — University of Warwick, Gibbet Hill Road, Coventry CV47AL, UK

We numerically investigate the interplay of disorder and electron-electron interactions in the integer quantum Hall effect. In particular, we focus on the behaviour of the electronic compressibility as a function of magnetic field and electron density. We find manifestations of non-linear screening and charging effects around integer filling factors, consistent with recent imaging experiments. Our calculations exhibit g-factor enhancement as well as strong overscreening in the centre of the Landau bands. Even though the critical behaviour appears mostly unaffected by interactions, important implications for the phase diagram arise. Our results are in very good agreement with the experimental findings and strongly support the relevance of electron-electron interactions for understanding integer quantum Hall physics.

HL 47.7 Thu 17:15 H14

Phonon Drag in High Landau Levels — •Christian Joas and Jürgen Dietel — Institut für theoretische Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin

The information provided by drag measurements in bilayer quantum Hall systems subjected to a perpendicular magnetic field is complementary to conventional transport measurements and thus constitutes a valuable additional tool for the investigation of quantum Hall systems. Most experimental and theoretical work is focused on the study of Coulomb drag, which, for small interlayer separations, yields the dominant contribution to the drag conductivity. For larger interlayer separations, also phonon-mediated interlayer interactions become relevant. In contrast to the case of Coulomb drag, where the drag conductivity is dominated by small momentum tranfers between the layers, the momentum transfers involved in phonon drag can be of the order of the Fermi momentum. By generalizing the linear response theory of

Coulomb drag [1] to arbitrary momentum tranfers, we derive a theory of phonon drag in high Landau levels and present analytical and numerical results for the phonon-mediated contribution to the drag conductivity. We show that the temperature dependence of phonon drag differs strongly from the behavior of Coulomb drag. We also compare our results with experiments for phonon drag at zero magnetic field [2].

[1] I. V. Gornyi, A. D. Mirlin, and F. von Oppen, Phys. Rev. B **70**, 245302 (2004). [2] T. J. Gramila, J. P. Eisenstein, A. H. MacDonald, L. N. Pfeiffer, and K. W. West, Phys. Rev. Lett. **66**, 1216 (1991).

HL 47.8 Thu 17:30 H14

Shadow epitaxy technique for fabricating complex coplanar 2D structures — •N. Isik, S. F. Roth, M. Bichler, A. Fontcuberta i Morral, and M. Grayson — Walter Schottky Institute ,Technische Universität München, Am Coulombwall 3, 85748 Garching , Germany

Advanced growth techniques are required to fabricate complex 2D heterostructures, however such approaches often need special postgrowth processes, i.e. regrowth over a patterned back gate, selective ion implantation, cleaved-edge overgrowth, flip-chip bonding, V-groove regrowth. We introduce here a new shadow epitaxy technique whose most important advantage is the ability to grow complex devices with a single growth process, requiring only standard photolithography to achieve a final device. Our technique requires only tall rectangular pieces of GaAs wafer mounted perpendicular to the substrate for creating shadows. During the growth, the substrate is arranged at specific angles relative to the cell positions in the MBE chamber causing specific layers of the heterostructure to be absent in the shadow region. By using this shadow epitaxy technique, two type of structures will be demonstrated. First, localized superlattice shadow structures are analyzed by using scanning electron microscopy (SEM). Second, the transport properties of modulation doped high mobility $n-$ and $p-$ type coplanar 2D shadows will be characterized.

HL 47.9 Thu 17:45 H14

Temperature dependence of high mobility AlAs quantum wells — •Shivaji Dasgupta, Claudius Knaak, Max Bichler, Anna Fontcuberta-i-Morral, Gerhard Abstreiter, and Matthew Grayson — Walter Schottky Institute, Technische Universität München, Am Coulombwall 3, Garching

We present transport characteristics of high mobility n-type AlAs quantum well (QW) substrates grown on two different facets (001) and (110). Measurements were performed down to 330 mK on van der Pauw geometries and on L-shaped Hall bars with the arms oriented along the crystallographic axes to investigate mobility anisotropies. In the (001) oriented QW, the presence of two degenerate valleys of electrons yields a total isotropic conductance with a mobility of 2.4×10^5 cm^2/Vs at 1.4 K, with the mobility saturating below 3 K. In the (110) oriented QW, there should be a single valley with an anisotropic conductance. At 1.4 K we obtain mobilities of 3.4×10^3 cm^2/Vs along the $\langle$ 001 $\rangle$ branch of the L-shaped Hall bar and 1.8×10^4 cm^2/Vs on the $\langle$ -110 $\rangle$ branch. The ratio of 5.8 between the two mobilities matches the ratio between the two anisotropic masses, $m_l/m_t = 1.1/0.19 = 5.8$. The temperature dependence has been analyzed in analogy to mobility limiting processes at low temperatures in GaAs [1], which include remote-ion scattering due to donors, ionized impurity scattering due to interface charge, polar optical phonon scattering, acoustic deformation potential scattering and piezoelectric scattering among others. Evidence of an additional inter-valley scattering term in the mobility will be explored.

[1] Lin, et al. Appl. Phys. Lett. 45, 695 (1984).

HL 47.10 Thu 18:00 H14

Two beam Aharonov-Bohm interference in the integer quantum Hall regime — •Leonid Litvin, Peter Tranitz, Werner Wegscheider, and Christoph Strunk — Uni Regensburg

We have built an electronic Mach-Zehnder interferometer (MZI) [1] using high mobility GaAs/AlGaAs heterostructures with the purpose to study electron interference and shot noise in this system. The maximum interference visibility of our device was near 20% at filling factor ν=1. It was found earlier that the Aharonov-Bohm oscillation amplitude varies nonmonotonically with energy [2]. We confirm this behavior for a MZI 1.5 times bigger in size with about 1.4 times higher electron density. In spite of these difference the characteristic energy in our experiment was found to be 10 μV, similar as in [2]. The interference appears in a broad range of magnetic field between filling factors 1 and 2. The visibility is highest at certain resonances in the transmission of the quantum point contact. [1] Yang Ji *et al.*, Nature **422**, 415 (2003) [2] I. Neder *et al.*, Phys.Rev.Lett. **96**, 016804 (2006).